(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 186 119**
A2

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: 85116166.1

(22) Date of filing: 18.12.85

(51) Int. Cl.⁴: C 07 C 147/06
C 07 C 143/14, C 07 C 149/32
A 01 N 41/10, A 01 N 31/08

(30) Priority: 20.12.84 US 683898

(43) Date of publication of application:
02.07.86 Bulletin 86/27

(84) Designated Contracting States:
AT BE CH DE FR GB IT LI NL SE

(71) Applicant: STAUFFER CHEMICAL COMPANY
Westport Connecticut 06881(US)

(72) Inventor: Carter, Charles Garvie
1240 Willard Street
San Francisco, Calif. 94117(US)

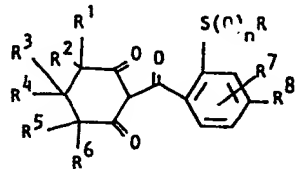
(72) Inventor: Lee, David Louis
227 Jenay Court
Martinez, Calif. 94533(US)

(72) Inventor: Michaely, William James
3161 Birmingham Drive
Richmond, Calif. 94806(US)

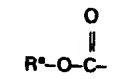
(74) Representative: Kraus, Walter, Dr. et al,
Patentanwälte Kraus, Weisert & Partner
Thomas-Wimmer-Ring 15
D-8000 München 22(DE)

(54) **Certain 2-(2'substituted benzoyl)-1,3-cyclohexanediones.**

(57) Compounds of the formula



wherein n is the integer 0, 1 or 2; R is C_1-C_4 alkyl; R^1 is hydrogen or C_1-C_4 alkyl; R^2 is hydrogen, C_1-C_4 alkyl or



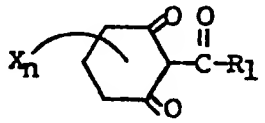
wherein R^a is C_1-C_4 alkyl; R^1 and R^2 together are alkylene having 3 to 6 carbon atoms; R^3 is hydrogen or C_1-C_4 alkyl; R^4 is hydrogen or C_1-C_4 alkyl; R^5 is hydrogen or C_1-C_4 alkyl; R^6 is hydrogen or C_1-C_4 alkyl; and R^7 and R^8 independently are (1) hydrogen; (2) halogen; (3) C_1-C_4 alkyl; (4) C_1-C_4 alkoxy; (5) OCF_3; (6) cyano; (7) nitro; (8) C_1-C_4 haloalkyl; (9) R^bSO_n- wherein n is the integer 0, 1 or 2; and R^b is (a) C_1-C_4 alkyl; (b) C_1-C_4 alkyl substituted with halogen or cyano; (c) phenyl; or (d) benzyl; (10) -NR^cR^d wherein R^c and R^d independently are hydrogen or C_1-C_4 alkyl; (11) $R^aC(O)$-wherein R^a is C_1-C_4 alkyl or C^1-C_4 alkoxy; or (12) $SO_2NR^cR^d$ wherein R^c and R^d are as defined with the proviso that R^7 is not attached to the 6-position, are effective as herbicides.

EP 0 186 119 A2

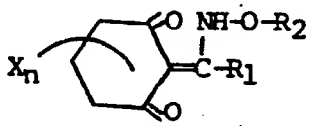
CERTAIN 2-(2'-SUBSTITUTED BENZOYL)-1,3-CYCLOHEXANEDIONES

Background of the Invention

Compounds having the structural formula



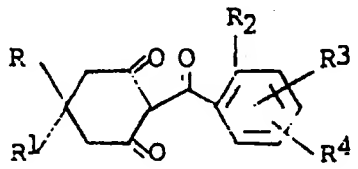
wherein X can be an alkyl, n can be 0, 1, or 2, and R_1 can be phenyl or substituted phenyl are described in Japanese Patent Application 84632-1974 as being intermediates for the preparation of herbicidal compounds of the formula



wherein R_1, X, and n are as defined above and R_2 is alkyl, alkenyl, or alkynyl. Specifically taught herbicidal compounds of this latter group are those where n is 2, X is 5,5-dimethyl, R_2 is allyl and R_1 is phenyl, 4-chlorophenyl or 4-methoxyphenyl.

The precursor intermediates for these three specifically taught compounds have no or almost no herbicidal activity.

European Patent Application No. 83 102 599.4 was published October 5, 1983 and relates to certain novel 2-(2-substituted benzoyl)-cyclohexane-1,3-diones as herbicides. The compounds have the following structural formula



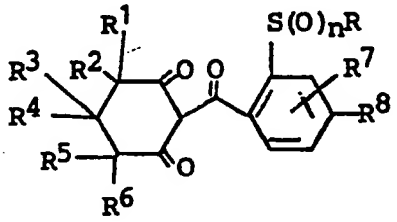
wherein R and R^1 are hydrogen or C_1-C_4 alkyl; R^2 is chlorine, bromine, or iodine; R^3 is hydrogen or halogen; and R^4 is hydrogen, chlorine, bromine, iodine, C_1-C_4 alkyl, C_1-C_4 alkoxy, nitro or trifluoromethyl.

Description of the Invention

This invention relates to 2-(2-benzoyl)-1,3-cyclohexanediones and their use as herbicides.

One embodiment of this invention is an herbicidal composition comprising an herbicidally active 2-(2-C_1-C_4 alkylthio, C_1-C_4 alkylsulfinyl or C_1-C_4 alkylsulfonyl benzoyl)-1,3-cyclohexanedione and an inert carrier therefor. The 4-, 5- and 6-positions of the 1,3-cyclohexanedione moiety can be substituted, preferably with the groups hereinafter recited. More preferably, the 1,3-cyclohexanedione moiety has no substitution or the 4- or 6-positions are substituted with one or two methyl groups. The 3-, 4- and 5-positions of the benzoyl moiety can be substituted, preferably with the groups hereinafter recited.

Also embodied with the scope of this invention are novel compounds having the structural formula



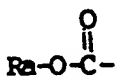
wherein

n is the integer 0, 1 or 2, preferably 2;

R is C_1-C_4 alkyl, preferably methyl;

R^1 is hydrogen or C_1-C_4 alkyl, preferably C_1-C_2 alkyl, more preferably methyl, most preferably R^1 is hydrogen or methyl;

R^2 is hydrogen; C_1-C_4 alkyl, preferably C_1-C_2 alkyl, more preferably methyl or



wherein R^a is C_1-C_4 alkyl, most preferably R^2 is hydrogen or methyl; or

R^1 and R^2 together are alkylene having 3 to 6 carbon atoms;

R^3 is hydrogen or C_1-C_4 alkyl, preferably C_1-C_2 alkyl, more preferably methyl; most preferably R^3 is hydrogen or methyl;

R^4 is hydrogen or C_1-C_4 alkyl, preferably C_1-C_2 alkyl, more preferably methyl; most preferably R^4 is hydrogen or methyl;

R^5 is hydrogen or C_1-C_4 alkyl, preferably C_1-C_2 alkyl, more preferably methyl; most preferably R^5 is hydrogen or methyl;

R^6 is hydrogen or C_1-C_4 alkyl, preferably C_1-C_2 alkyl, more preferably methyl, most preferably R^6 is hydrogen;

R^7 and R^8 independently are (1) hydrogen; (2) halogen, preferably chlorine, fluorine or bromine; (3) C_1-C_4 alkyl, preferably methyl; (4) C_1-C_4 alkoxy, preferably methoxy; (5) OCF_3; (6) cyano; (7) nitro; (8) C_1-C_4 haloalkyl, more preferably trifluoromethyl; (9) R^bSO_n- wherein n is the integer 0, 1 or 2, preferably 2; and

R^b is (a) C_1-C_4 alkyl, preferably methyl;

(b) C_1-C_4 alkyl substituted with halogen or cyano, preferably chloromethyl, trifluoromethyl or cyanomethyl;

(c) phenyl; or

(d) benzyl;

(10) $-NR^cR^d$ wherein

R^c and R^d independently are hydrogen or C_1-C_4 alkyl;

(11) $R^eC(O)$- wherein

R^e is C_1-C_4 alkyl or C_1-C_4 alkoxy; or

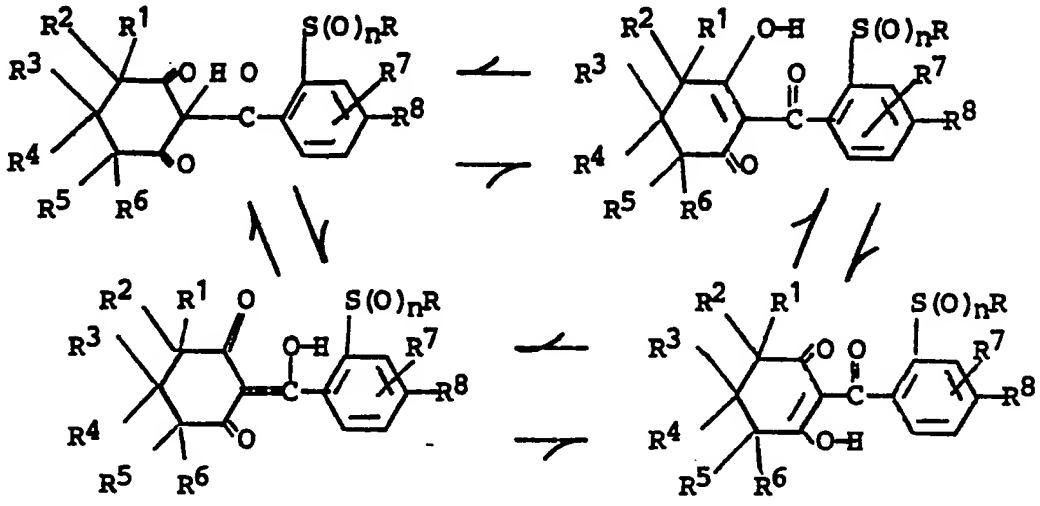
(12) $-SO_2NR^cR^d$ wherein R^c and R^d are as defined, with the proviso that R^7 is not attached to the 6-position.

Preferably, R^7 is in the 3-position. Most preferably R^7 is hydrogen or 3-chlorine and R^8 is hydrogen, chlorine, bromine, fluorine, CF_3, or R^bSO_2 wherein R^b is C_1-C_4 alkyl, preferably methyl.

The term "C_1-C_4" alkyl includes methyl, ethyl, n-propyl, isopropyl, n-butyl, sec-butyl, isobutyl and t-butyl. The term "halogen" includes chlorine, bromine, iodine and fluorine. The term "C_1-C_4 alkoxy" includes methoxy, ethoxy, n-propoxy, isopropoxy, n-butoxy, sec-butoxy, isobutoxy and t-butoxy. The term "haloalkyl" includes the eight alkyl groups with one or more hydrogens replaced by chloro, bromo, iodo or fluoro.

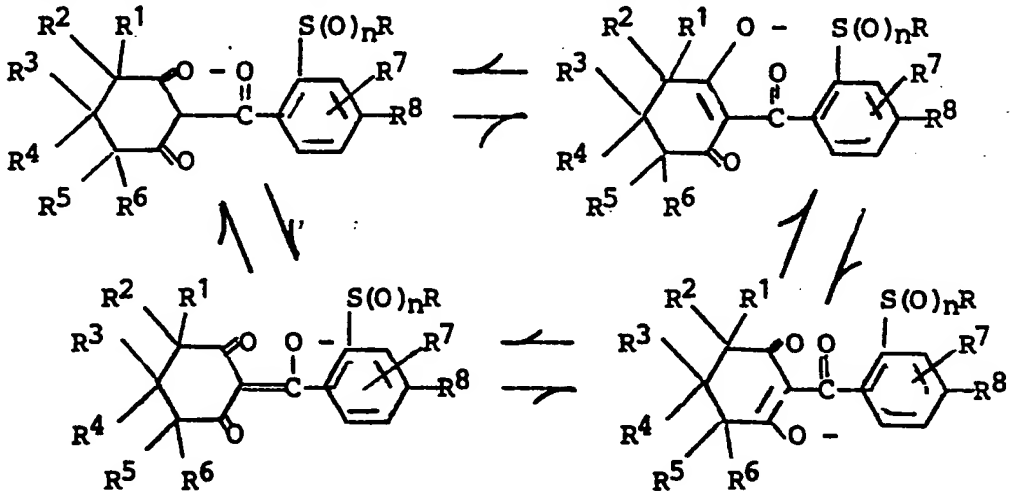
Salts of the above-described compounds (as defined hereinafter) are also the subject of the instant invention.

The compounds of this invention can have the following four structural formulae because of tautomerism:



wherein n, R, R^1, R^2, R^3, R^4, R^5, R^6, R^7 and R^8 are as defined above.

The circled proton on each of the four tautomers is reasonably labile. These protons are acidic and can be removed by any base to give a salt having an anion of the following four resonance forms:



wherein n, R, R^1, R^2, R^3, R^4, R^5, R^6, R^7 and R^8 are as defined above.

Examples of cations of these bases are inorganic cations such as alkali metals e.g. lithium, sodium, and potassium, organic cations such as

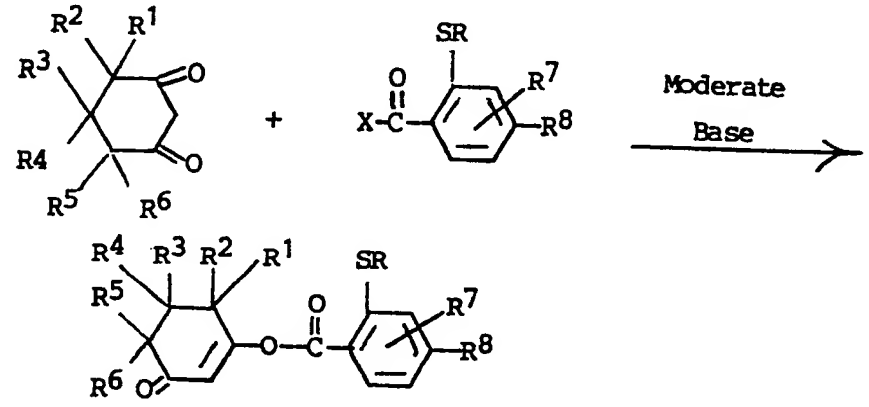
substituted ammonium, sulfonium or phosphonium wherein the substitutent is an aliphatic or aromatic group.

The compounds of this invention and their salts are active herbicides of a general type. That is, they are herbicidally effective against a wide range of plant species. The method of controlling undesirable vegetation of the present invention comprises applying an herbicidally effective amount of the above-described compounds to the area where control is desired.

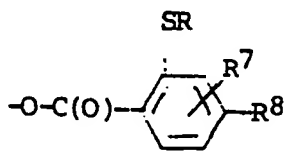
The compounds of the present invention can be prepared by the following two or three step general method.

The process proceeds via the production of an enol ester intermediate as shown in reaction (1). The final product is obtained by rearrangement of the enol ester as shown in reaction (2). The two reactions may be conducted as separate steps by isolation and recovery of the enol ester using conventional techniques prior to conducting step (2), or by addition of a cyanide source to the reaction medium after the formation of the enol ester, or in one step by inclusion of the cyanide source at the start of reacton (1).

1)



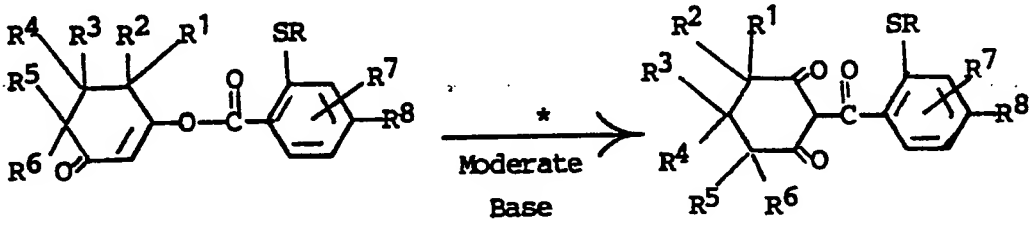
wherein moderate base, and R through R^8 are defined herein, and and n X is halogen, preferably chlorine, C_1-C_4 alkyl-C(O)-O-, C_1-C_4 alkoxy-C(O)-O- or



wherein R, R^7 and R^8 in this portion of the moledule are identical with those in the reactant shown above, and the moderate base is as defined, preferably tri-C_1-C_6 alkylamine, pyridine, alkali metal carbonate or alkali metal phosphate.

Generally, in step (1) mole amounts of the dione and substituted benzoyl reactant are used, along with a mole amount or excess of the base. The two reactants are combined in an organic solvent such as methylene chloride, toluene, ethyl acetate or dimethylformamide. The base or benzoyl reactant preferably are added to the reaction mixture with cooling. The mixture is stirred at 0°C-50°C until the reaction is substantially complete.

2)



* = Cyanide source as defined herein. Moderate Base = As defined herein.

Generally, in step (2) a mole of the enol ester intermediate is reacted with 1 to 4 moles of the base, preferably about 2 moles of moderate base and from 0.01 mole to about 0.5 mole or higher, preferably around 0.1 mole of the cyanide source (e.g., potassium cyanide or acetonecyanohydrin). The mixture is stirred in a reaction pot until the rearrangement is substantially complete at a temperature below 50°C, preferably about 20°C to about 40°C, and the desired product is recovered by conventional techniques.

The term "cyanide source" refers to a substance or substances which under the rearrangement conditions consists of or generates hydrogen cyanide and/or cyanide anion.

The process is conducted in the presence of a catalytic amount of a source of cyanide anion and/or hydrogen cyanide, together with a molar excess, with respect to the enol ester, of a moderate base.

Preferred cyanide sources are alkali metal cyanides such as sodium and potassium cyanide; cyanohydrins of methyl alkyl ketones having from 1-4 carbon atoms in the alkyl groups, such as acetone or methyl isobutyl ketone cyanohydrins; cyanohydrins of benzaldehyde or of C_2-C_5 aliphatic aldehydes such as acetaldehyde, propionaldehyde, etc., cyanohydrins; zinc cyanide; tri(lower alkyl) silyl cyanides, notably trimethyl silyl cyanide; and hydrogen cyanide itself. Hydrogen cyanide is considered most advantageous as it produces relatively rapid reaction and is inexpensive. Among cyanohydrins the preferred cyanide source is acetone cyanohydrin.

The cyanide source is used in an amount up to about 50 mole percent based on the enol ester. It may be used in as little as about 1 mole percent to produce an acceptable rate of reaction at about 40°C on a small scale. Larger scale reactions give more reproducible results with slightly higher catalyst levels of about 2 mole percent. Generally about 1-10 mole % of the cyanide source is preferred.

The process is conducted with a molar excess, with respect to the enol ester, of a moderate base. By the term "moderate base" is meant a substance which acts as a base yet whose strength or activity as a base lies between that of strong bases such as hydroxides (which could cause hydrolysis of the enol ester) and that of weak bases such as bicarbonates (which would not function effectively). Moderate bases suitable for use in this embodiment include both organic bases such as tertiary amines and inorganic bases such as alkali metal carbonates and phosphates. Suitable tertiary amines include trialkylamines such as triethylamine, trialkanolamines such as triethanolamine, and pyridine. Suitable inorganic bases include potassium carbonate and trisodium phosphate.

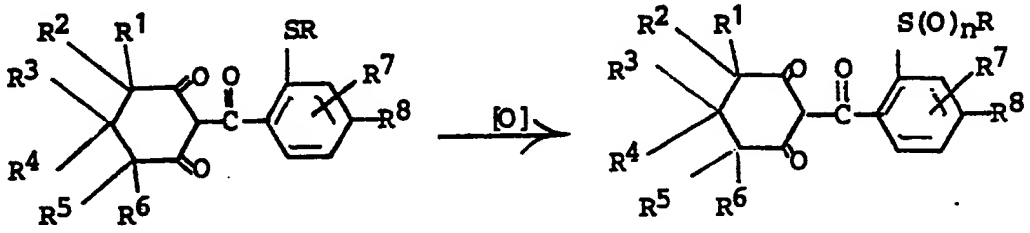
The base is used in an amount of from about 1 to about 4 moles per mole of enol ester, preferably about 2 moles per mole.

When the cyanide source is an alkali metal cyanide, particularly potassium cyanide, a phase transfer catalyst may be included in the reaction. Particularly suitable phase transfer catalysts are the Crown ethers.

A number of different solvents may be usable in this process, depending on the nature of the acid chloride or the acylated product. A preferred solvent for this reaction is 1,2-dichloroethane. Other solvents which may be employed, depending on the reactants or products include toluene, acetonitrile, methylene chloride, ethyl acetate, dimethylformamide, and methyl isobutyl ketone (MIBK).

In general, depending on the nature of the reactants and the cyanide source, the rearrangment may be conducted at temperatures up to about 50°C.

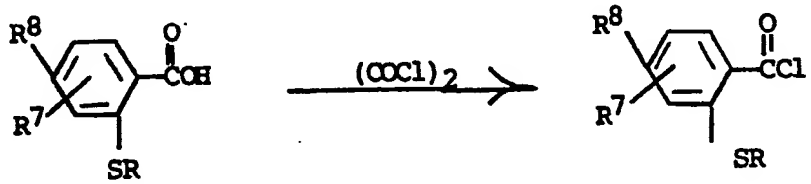
3)



wherein n is 1 or 2.

Generally in step (3), a mole of the reaction product of step (2) is reacted with a slight mole or two mole excess of of an oxidizing agent such as m-chloroperbenzoic acid after being dissolved in a solvent such as methylene chloride. After completion of the reaction, the resulting mixture is stripped under vacuum. The residue is purified by silica gel chromatography to yield the desired product.

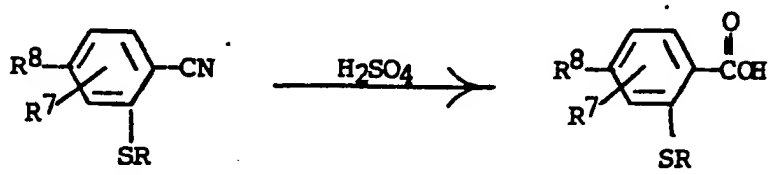
The above described substituted benzoyl chlorides can be prepared from the corresponding substituted benzoic acids according to the teaching of Reagents for Organic Synthesis, Vol. I, L.F. Fieser and M. Fieser, pp. 767-769 (1967).



wherein R, R^7 and R^8 are as previously defined.

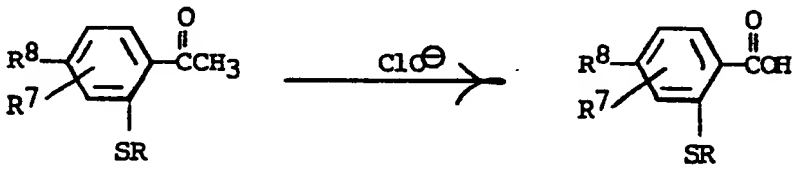
The substituted benzoic acids can be prepared by a wide variety of general methods according to the teaching of The Chemistry of Carboxylic Acids and Esters, S. Patai, editor, J. Wiley and Sons, New York, N.Y. (1969) and Survey of Organic Synthesis, C.A. Buehler and D.F. Pearson, J. Wiley and Sons, (1970).

The following are three representative examples of the methods described therein.

a) 

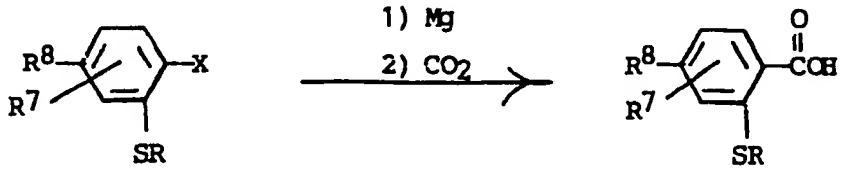
wherein R, R^7 and R^8 are as previously defined.

In reaction (a) the substituted benzonitrile is heated to reflux in aqueous sulfuric acid for several hours. The mixture is cooled and the reaction product is isolated by conventional techniques.

b) 

wherein R, R^7 and R^8 are as previously defined.

In reaction (b) the substituted acetophenone is heated to reflux for several hours in an aqueous hypochlorite solution. The mixture is cooled and the reaction product is isolated by conventional techniques.

c) 

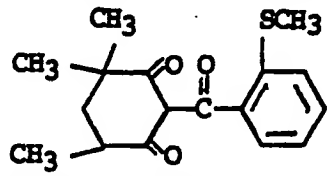
wherein R, R^7 and R^8 are as defined and X is chlorine, bromine or iodine.

In reaction (c) the substituted aromatic halide is allowed to react with magnesium in a solvent such as ether. The solution is then poured over crushed dry ice and the benzoic acid is isolated by conventional techniques.

The following examples teach the synthesis representative compounds of this invention.

EXAMPLE 1

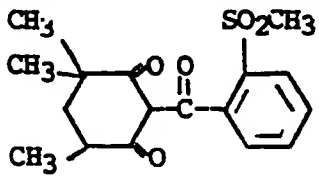
2-(2'-Methylthiobenzoyl)-4,4,6-trimethyl-1,3-cyclohexanedione



2-Methylthiobenzoyl chloride (7.2 g, 39 mmol) and 4,4,6-trimethylcyclohexanedione (5.0 g, 39 mmol) were dissolved in methylene chloride. Triethylamine (7.0 ml, 50 mmol) was added dropwise and the resulting solution stirred for one hour at room temperature. The solution was washed with 2 normal hydrochloric acid (2N HCl), 5% potassium carbonate solution (5% K_2CO_3) and saturated sodium chloride solution (brine), dried over anhydrous magnesium sulfate ($MgSO_4$) and concentrated under vacuum. The residue was dissolved in 20 ml acetonitrile. Triethylamine (2.5 equivalents) and acetone cyanohydrin (0.4 ml) were added and the solution stirred for 45 minutes at room temperature. After dilution with ether, the solution was washed with 2N HCl and extracted with 5% K_2CO_3. The aqueous extract was acidified with hydrochloric acid and extracted with ether. The ether was washed with brine, dried ($MgSO_4$) and concentrated under vacuum. The residue was purified by trituration with ether, yielding 5.0 g of a viscous oil which was identified as the desired compound by nuclear magnetic resonance spectroscopy (nmr), infrared spectroscopy (ir) and mass spectroscopy (ms).

EXAMPLE 2

2-(2'-Methanesulfonylbenzoyl)-4,4,6-trimethyl-1,3-cyclohexanedione

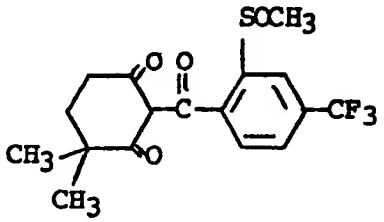


The benzoyl cyclohexanedione prepared in Example 1 (2.5 g, 7.9 mmol) was dissolved in 40 ml methylene chloride. m-Chloroperbenzoic acid (3.5 g, 16 mmol) was added and the resulting solution was stirred for 45 minutes. The solution was concentrated under vacuum. Purification of the

residue by silica gel chromatography yielded 1.7 g of a viscous oil which was identified as the desired compound by nmr, ir and ms.

EXAMPLE 3

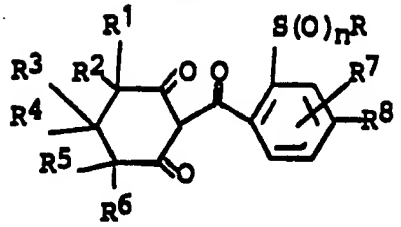
2-(4'-Trifluoromethyl-2'-methanesulfinylbenzoyl)-4,4-dimethyl-1,3-cyclohexanedione



2-(4'-Trifluoromethyl-2'-methylthiobenzoyl)-4,4-dimethyl-1,3-cyclohexanedione (5.0 g, 14 mmol) (which was prepared according to the method of Example 1) was dissolved in 50 ml methylene chloride. A solution of m-chloroperbenzoic acid (2.4 g - 80%, 14 mmol) in 50 ml methylene chloride was added dropwise and the resulting solution was stirred for three hours at room temperature. After concentration under vacuum, the residue was dissolved in ether and washed with 1% hydrochloric acid. A 5% copper(II) acetate solution was added to the ether fraction, followed by hexane. The liquid phase was decanted and the remaining gummy solid stirred with 6N HCl and ether. The ether layer was dried ($MgSO_4$) and concentrated to give 4.7 of a thick yellow solid. Purification on a centrifugally accelerated thin layer chromatograph (4 mm silica gel, 50:50:1 hexane:ethyl acetate:acetic acid - eluent) yielded 2.4 g of a viscous oil which was identified as the desired compound by nmr, ir and ms.

The following is a table of certain selected compounds that are preparable according to the procedure described hereto. Compound numbers are assigned to each compound and are used throughout the remainder of the application.

TABLE I



Comp. No.	n	R	R^1	R^2	R^3	R^4	R^5	R^6	R^7	R^8	m.p.
1	0	CH_3	H	H	H	H	H	H	H	H	79–81°C
2	0	CH_3	CH_3	CH_3	H	H	H	H	H	H	oil
3a)	0	CH_3	CH_3	CH_3	H	H	CH_3	H	H	H	oil
4b)	2	CH_3	CH_3	CH_3	H	H	CH_3	H	H	H	oil
5	0	C_2H_5	CH_3	CH_3	H	H	H	H	H	H	oil
6	2	C_2H_5	CH_3	CH_3	H	H	H	H	H	H	oil
7	0	CH_3	H	H	H	H	H	H	3-Cl	Cl	59–64°C
8	2	CH_3	H	H	H	H	H	H	3-Cl	Cl	116–119°C
9	0	CH_3	H	H	H	H	H	H	H	CF_3	102–106°C
10	2	CH_3	H	H	H	H	H	H	H	CF_3	oil
11	0	CH_3	CH_3	CH_3	H	H	H	H	H	CF_3	49–53°C
12	2	CH_3	CH_3	CH_3	H	H	H	H	H	CF_3	oil
13c)	1	CH_3	CH_3	CH_3	H	H	H	H	H	CF_3	oil
14	0	CH_3	H	H	H	H	H	H	3-Cl	$-SCH_3$	105–107°C
15	1	CH_3	H	H	H	H	H	H	3-Cl	$-S(O)CH_3$	oil
16	0	CH_3	H	H	H	H	H	H	H	$-SO_2n-C_3H_7$	oil
17	0	CH_3	H	H	H	H	H	H	H	$-SCH_3$	101–103°C
18	2	CH_3	H	H	H	H	H	H	H	$-SO_2n-C_3H_7$	oil
19	2	CH_3	H	H	H	H	H	H	H	$-SO_2CH_3$	194–196°C
20	0	CH_3	H	H	H	H	H	H	3-CH_3	H	40–42°C
21	2	CH_3	H	H	H	H	H	H	3-CH_3	H	80–86°C

a) Prepared in Example 1.

b) Prepared in Example 2.

c) Prepared in Example 3.

Herbicidal Screening Tests

As previously mentioned, the herein described compounds produced in the above-described manner are phytotoxic compounds which are useful and valuable in controlling various plant species. Selected compounds of this invention were tested as herbicides in the following manner.

Pre-emergence herbicide test. On the day preceding treatment, seeds of eight different weed species are planted in loamy sand soil in individual rows using one species per row across the width of a flat. The seeds used are green foxtail (FT) (Setaria viridis), watergrass (WG) (Echinochloa crusgalli), wild oat (WO) (Avena fatua), annual morningglory (AMG) (Ipomoea lacunosa), velvetleaf (VL) (Abutilon theophrasti), Indian mustard (MD) (Brassica juncea), curly dock (CD) (Rumex crispus), and yellow nutsedge (YNG) (Cyperus esculentus). Ample seeds are planted to give about 20 to 40 seedlings per row, after emergence, depending upon the size of the plants.

Using an analytical balance, 600 milligrams (mg) of the compound to be tested are weighed out on a piece of glassine weighing paper. The paper and compound are placed in a 60 milliliter (ml) wide-mouth clear bottle and dissolved in 45 ml of acetone or substituted solvent. Eighteen ml of this solution are transferred to a 60 ml wide-mouth clear bottle and diluted with 22 ml of a water and acetone mixture (19:1) containing enough polyoxyethylene sorbitan monolaurate emulsifier to give a final solution of 0.5% (v/v). The solution is then sprayed on a seeded flat on a linear spray table calibrated to deliver 80 gallons per acre (748 L/ha). The application rate is 4 lb/acre (4.48 Kg/ha).

After treatment, the flats are placed in the greenhouse at a temperature of 70 to 80°F and watered by sprinkling. Two weeks after treatment, the degree of injury or control is determined by comparison with untreated check plants of the same age. The injury rating from 0 to 100% is recorded for each species as percent control with 0% representing no injury and 100% representing complete control.

The results of the tests are shown in the following Table II.

TABLE II

Pre-Emergence Herbicidal Activity
Application Rate — 4.48 kg/ha

Cmpd. No.	FT	WG	WO	AMG	VL	MD	CD	YNG
1	0	0	0	0	0	0	0	20
2	25	30	30	0	70	0	40	30
3	25	20	0	0	0	0	0	0
4	100	100	90	60	100	100	100	90
5	50	60	40	50	50	60	90	50
6	100	95	50	40	40	60	99	70
16	80	100	50	60	100	90	90	90
20	100	100	30	15	100	100	90	85
21	100	100	-	30	100	95	100	80

A blank (-) indicates that the weed was not tested.

Post-Emergence Herbicide Test: This test is conducted in an identical manner to the testing procedure for the pre-emergence herbicide test, except the seeds of the eight different weed species are planted 10-12 days before treatment. Also, watering of the treated flats is confined to the soil surface and not to the foliage of the sprouted plants.

The results of the post-emergence herbicide test are reported in Table III.

TABLE III

Post-Emergence Herbicidal Activity
Application Rate — 4.48 kg/ha

Cmpd. No.	FT	WG	WO	AMG	VL	MD	CD	YNG
1	20	20	10	20	40	40	20	40
2	0	60	60	50	70	30	0	15
3	20	20	0	10	0	20	0	20
4	85	90	100	45	75	30	80	65
5	55	50	60	50	75	85	65	-
6	70	70	50	60	80	70	90	-
16	95	95	40	100	100	100	100	90
20	95	75	35	40	95	75	35	80
21	80	70	30	45	80	90	50	70

A blank (-) indicates the weed was not tested.

Pre-Emergence Multi-Weed Herbicide Test: Several compounds were evaluated at an application rate of 2 or 1 lb/acre (2.24 or 1.12 kg/ha) for preemergence activity against a larger number of weed species.

The process was generally similar to the pre-emergence herbicide test described above except that only 300, 150 or 37.5 milligrams of test compound were weighed out and the application rate was 40 gallons per acre.

Redroot pigweed (PW) and curly dock (CD) were eliminated in this test and the following weed species were added:

Grasses:	downy brome	Bromus tectorum	(DB)
	annual ryegrass	Lolium multiflorum	(ARG)
	Johnsongrass	Sorghum halepense	(JG)
	broadleaf signallgrass	Brachiaria platyphylla	(BSG)
	hemp sesbania	Sesbania exaltata	(SESB)
	sicklepod	Cassia obtusifolia	(SP)

The results of the test are shown in Tables IV and V.

TABLE IV

Pre-Emergence Multi-weed Herbicide Test

Application Rate - 2.24 kg/ha

Cmpd. No.	DB	FT	ARG	WG	JG	WO	BSG	AMG	SESB	VL	SP	MD	YNG
17	95	85	35	100	85	25	90	100	100	100	40	100	95
18	0	0	0	50	20	0	15	60	45	100	0	100	-

TABLE V

Pre-Emergence Multi-weed Herbicide Test

Application Rate - 1.12 kg/ha

Cmpd. No.	DB	FT	ARG	WG	JG	WO	BSG	AMG	SESB	VL	SP	MD	YNG
7	30	70	20	100	75	0	90	100	95	100	100	100	90
8	95	95	45	100	98	25	90	100	95	100	90	100	90
9	10	70	40	100	20	0	80	100	85	100	40	100	95
10	100	100	10	100	40	0	90	100	100	100	80	100	100
11	90	100	90	100	100	65	100	100	90	100	30	100	65
12	100	100	80	100	100	85	90	100	100	100	85	100	90
13	0	100	10	100	100	80	70	80	90	100	70	100	80
15	0	10	0	90	0	0	15	35	30	100	10	85	75
19	100	90	0	100	20	10	40	95	100	100	100	100	65

Post-Emergence Multi-Weed Herbicide Test: This test is conducted in an identical manner to the testing procedure for the post-emergence herbicide test, except the seeds of the eight weed species used in the pre-emergence multi-weed herbicide test were used and the seeds were planted 10-12 days before treatment. Also, watering of the treated flats is confined to the soil surface and not to the foliage of the sprouted plants.

The results of the post-emergence multi-weed herbicide test are reported in Tables VI and VII.

TABLE VI

Post-Emergence Multi-Weed Herbicidal Activity
Application Rate — 2.24 kg/ha

Cmpd. No.	DB	FT	ARG	WG	JG	WO	BSG	AMG	SESB	VL	SP	MD	YNG
17	80	100	55	95	90	20	60	100	100	100	75	100	70
18	0	100	0	98	20	0	10	70	60	100	10	100	45

TABLE VII

Post-Emergence Multi-Weed Herbicidal Activity
Application Rate — 1.12 kg/ha

Cmpd. No.	DB	FT	ARG	WG	JG	WO	BSG	AMG	SESB	VL	SP	MD	YNG
7	25	30	0	70	60	20	90	75	95	85	50	100	35
8	80	80	20	70	70	40	80	50	80	80	60	60	35
9	0	30	0	75	15	25	100	95	100	100	60	100	25
10	60	80	20	70	35	25	80	75	90	90	70	100	45
11	45	100	20	100	100	40	50	100	100	100	20	100	35
12	70	60	30	100	100	80	98	90	100	100	70	98	40
13	25	100	10	100	100	85	100	80	100	100	10	90	25
15	30	65	10	90	50	30	20	85	80	98	30	65	15
19	20	60	10	90	10	15	90	100	100	70	100	40	85

The compounds of the present invention are useful as herbicides and can be applied in a variety of ways at various concentrations. In practice, the compounds herein defined are formulated into herbicidal compositions, by admixture, in herbicidally effective amounts, with the adjuvants and carriers normally employed for facilitating the dispersion of active ingredients for agricultural applications, recognizing the fact that the formulation and mode of application of a toxicant may affect the activity of the materials in a given application. Thus, these active herbicidal compounds may be formulated as granules of relatively large particle size, as wettable powders, as emulsifiable concentrates, as as solutions or as any of several other known types of formulations, depending upon the desired mode of other known types of formulations, depending upon the desired mode of application. Preferred formulations for pre-emergence herbicidal applications are wettable powders, emulsifiable concentrates and granules. These formulations may contain as little as about 0.5% to as much as about 95% or more by weight of active ingredient. A herbicidally effective amount depends upon the nature of the seeds or plants to be controlled and the rate of application varies from about 0.05 to approximately 25 pounds per acre, preferably from about 0.1 to about 10 pounds per acre.

Wettable powders are in the form of finely divided particles which disperse readily in water or other dispersants. The wettable powder is ultimately applied to the soil either as a dry dust or as a dispersion

in water or other liquid. Typical carriers for wettable powders include fuller's earth, kaolin clays, silicas and other readily wet organic or inorganic diluents. Wettable powders normally are prepared to contain about 5% to about 95% of the active ingredient and usually also contain a small amount of wetting, dispersing, or emulsifying agent to facilitate wetting and dispersion.

Emulsifiable concentrates are homogeneous liquid compositions which are dispersible in water or other dispersant, and may consist entirely of the active compound with a liquid or solid emulsifying agent, or may also contain a liquid carrier, such as xylene, heavy aromatic naphthal, isophorone and other non-volatile organic solvents. For herbicidal application, these concentrates are dispersed in water or other liquid carrier and normally applied as a spray to the area to be treated. The percentage by weight of the essential active ingredient may vary according to the manner in which the composition is to be applied, but in general comprises about 0.5% to 95% of active ingredient by weight of the herbicidal composition.

Granular formulations wherein the toxicant is carried on relatively coarse particles, are usually applied without dilution to the area in which suppression of vegetation is desired. Typical carriers for granular formulations include sand, fuller's earth, bentonite clays, vermuculite, perlite and other organic or inorganic materials which absorb or which may be coated with the toxicant. Granular formulations normally are prepared to contain about 5% to about 25% of active ingredients which may include surface-active agents such heavy aromatic naphthas, kerosene or other petroleum fractions, or vegetable oils; and/or stickers such as destrins, glue or synthetic resins.

Typical wetting, dispersing or emulsifying agents used in agricultural formulations include, for example, the alkyl and alkylaryl sulfonates and sulfates and their sodium salts; polyhydric alcohols; and other types of surface-active agents, many of which are available in commerce. The surface-active agent, when used, normally comprises from 0.1% to 15% by weight of the herbicidal composition.

Dusts, which are free-flowing admixtures of the active ingredient with finely divided solids such as talc, clays, flours and other organic and inorganic solids which act as dispersants and carriers for the toxicant, are useful formulations for soil-incorporating application.

Pastes, which are homogeneous suspensions of a finely divided solid toxicant in a liquid carrier such as water or oil, are employed for specific purposes. These formulations normally contain about 5% to about 95% of active ingredient by weight, and may also contain small amounts of a wetting, dispersing or emulsifying agent to facilitate dispersion. For application, the pastes are normally diluted and applied as a spray to the area to be affected.

Other useful formulations for herbicidal applications include simple solutions of the active ingredient in a dispersant in which it is completely soluble at the desired concentration, such as acetone, alkylated naphthalenes, xylene and other organic solvents. Pressurized sprays, typically aerosols, wherein the active ingredient is dispersed in finely-divided form as a result of vaporization of a low boiling dispersant solvent carrier, such as the Freons, may also be used.

The phytotoxic compositions of this invention are applied to the plants in the conventional manner. Thus, the dust and liquid compositions can be applied to the plant by the use of power-dusters, boom and hand sprayers and spray dusters. The compositions can also be applied from airplanes as a dust or a spray because they are effective in very low dosages. In order to modify or control growth of germinating seeds or emerging seedlings, as a typical example, the dust and liquid compositions are applied to the soil according to conventional methods and are distributed in the soil to a depth of at least 1/2 inch below the soil surface. It is not necessary that the phytotoxic compositions be admixed with the soil particles since these compositions can also be applied merely by spraying or sprinkling the surface of the soil. The phytotoxic compositions of this invention can also be applied by addition to irrigation water supplied to the field to be treated. This method of application permits the penetration of the compositions into the soil as the water is absorbed therein. Dust compositions, granular compositions or liquid

formulations applied to the surface of the soil can be distributed below the surface of the soil by conventional means such as discing, dragging or mixing operations.

EMULSIFIABLE CONCENTRATE FORMULATIONS

General Formula with Ranges		Specific Formula	
Herbicidal compound	5-55	herbicidal compound	54
surfactant(s)	5-25	proprietary blend of oil-soluble sulfonates and polyoxyethylene ethers	10
solvent(s)	20-90	polar solvent	27
	100%	petroleum hydrocarbon	9
			100%

WETTABLE POWDER FORMULATIONS

herbicidal compound	3-90	herbicidal compound	80
wetting agent	0.5-2	sodium dialkyl naphthalene sulfonate	0.5
dispersing agent	1-8	sodium lignosulfonate	7
diluent(s)	8.5-87	attapulgite clay	12.5
	100%		100%

EXTRUDED GRANULAR FORMULATIONS

herbicidal compound	1-20	herbicidal compound	10
binding agent	0-10	lignin sulfonate	5
diluent(s)	70-99	calcium carbonate	85
	100%		100%

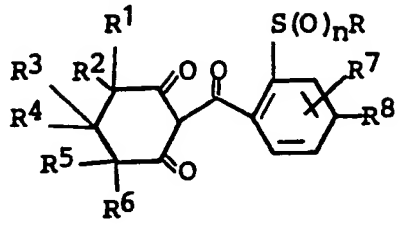
FLOWABLE FORMULATIONS

herbicidal compound	20-70	herbicidal compound	45
surfactant(s)	1-10	polyoxyethylene ether	5
suspending agent(s)	0.05-1	attagel	0.05
antifreeze agent	1-10	propylene glycol	10
antimicrobial agent	1-10	BIT	0.03
antifoam agent	0.1-1	silicone defoamer	0.02
solvent	7.95-77.85	water	39.9
	100%		100%

The phytotoxic compositions of this invention can also contain other additaments, for example, fertilizers and other herbicides, pesticides and the like, used as adjuvant or in combination with any of the above-described adjuvants. Other phytotoxic compounds useful in combination with the above-described compounds include, for example, anilides such as 2-benzothiazole-2-yloxy-N-methyl acetanilide, 2-chloro-2',6'-dimethyl-N-(n-propylethyl) acetanilide, 2-chloro-2',6'-diethyl-N-(butoxymethyl) acetanilide; 2,4-dichlorophenoxyacetic acids, 2,4,5-trichlorophenoxyacetic acid, 2-methyl-4-chlorophenoxyacetic acid and the salts, esters and amides thereof; triazine derivatives, such as 2,4-bis(3-methoxypropylamino)-6-methylthio-s-triazine, 2-chloro-4-ethylamino-6-isopropylamino-s-triazine, and 2-ethylamino-4-isopropyl-amino-6-methyl-mercapto-s-triazine; urea derivatives, such as 3-(3,5-dichlorophenyl)-1,1-dimethylurea and 3-(p-chlorophenyl)-1,1-dimethylurea; and acetamides such as N,N-diallyl-α-chloroacetamide, and the like; benzoic acids such as 3-amino-2,5-dichlorobenzoic acid; thiocarbamates such as S-(1,1-dimethylbenzyl)-piperidene-1-carbothioate, 3-(4-chlorophenyl)-methyl diethylcarbothioate, ethyl-1-hexahydro-1,4-azepine-1-carbothioate, S-ethyl-hexahydro-1H-azepine-1-carbothioate, S-propyl N,N-dipropylthiocarbamate, S-propyl N,N-di-n-propylthiocarbamate, S-ethyl cyclohexylethylthiocarbamate and the like; anilines such as 4-(methylsulfonyl)-2,6-dinitro-N,Nsubstituted aniline, 4-trifluoromethyl-2,6-dinitro-N,N-di-n-propyl aniline, 4-trifluoromethyl-2,6-dinitro-N-ethyl-N-butyl aniline, 2-[4-(2,4-dichlorophenoxy)phenoxy]-propanoic acid, 2-[1-(ethoxyimino)butyl]-5-[2-ethylthio)propyl]-3-hydroxy-2-cyclohexene-1-one, (±)-butyl-2-[4-[(5-trifluoromethyl)-2-pyridinyl)oxy]-phenoxy]propanate, sodium 5-[2-chloro-4-(trifluoromethyl)phenoxy]-2-fluoromethyl)phenoxy]-2-nitrobenzoate, 3-isopropyl-1H-2,1,3-benzothiadiazine-4(3H)-one-2,2-dioxide, and 4-amino-6-tert-butyl-3-(methylthio)-as-triazin-5(4H)-one or 4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one and S-(O,O-diisopropyl)-benzene sulfonamide. Fertilizers useful in combination with the active ingredients include, for example, ammonium nitrate, urea and superphosphate. Other useful additaments include materials in which plant organisms take root and grow such as compost, manure, humus, sand, and the like.

WHAT IS CLAIMED IS:

1. A compound of the formula



wherein

n is the integer 0, 1 or 2;

R is C_1-C_4 alkyl;

R^1 is hydrogen or C_1-C_4 alkyl;

R^2 is hydrogen, C_1-C_4 alkyl or R^a-O-C(=O)- wherein R^a is C_1-C_4 alkyl; or

R^1 and R^2 together are alkylene having 3 to 6 carbon atoms;

R^3 is hydrogen or C_1-C_4 alkyl;

R^4 is hydrogen or C_1-C_4 alkyl;

R^5 is hydrogen or C_1-C_4 alkyl;

R^6 is hydrogen or C_1-C_4 alkyl; and

R^7 and R^8 independently are (1) hydrogen; (2) halogen; (3) C_1-C_4 alkyl; (4) C_1-C_4 alkoxy; (5) OCF_3; (6) cyano; (7) nitro; (8) C_1-C_4 haloalkyl; (9) R^bSO_n- wherein n is the integer 0, 1 or 2; and R^b is (a) C_1-C_4 alkyl; (b) C_1-C_4 alkyl substituted with halogen or cyano; (c) phenyl; or (d) benzyl; (10) $-NR^cR^d$ wherein R^c and R^d independently are hydrogen or C_1-C_4 alkyl; (11) $R^eC(O)$- wherein R^e is C_1-C_4 alkyl or C_1-C_4 alkoxy; or (12) $SO_2NR^cR^d$ wherein R^c and R^d are as defined, with the proviso that R^7 is not attached to the 6-position.

2. The compounds of Claim 1 wherein n is 2; R is methyl; R^1 is hydrogen or methyl; R^2 is hydrogen or methyl; R^3 is hydrogen or methyl; R^4 is hydrogen or methyl; R^5 is hydrogen or methyl; R^6 is hydrogen or methyl; R^7 and R^8 independently are (1) hydrogen; (2) halogen; (3) C_1-C_4 alkyl; (4) C_1-C_4 alkoxy; (5) OCF_3; (6) cyano; (7) nitro; (8) C_1-C_4 haloalkyl; (9) R^bSO_n- wherein n is the integer 0, 1 or 2; and R^b is (a) C_1-C_4 alkyl; (b) C_1-C_4 alkyl substituted with halogen or cyano; (c) phenyl; or (d) benzyl; (10) $-NR^cR^d$ wherein R^c and R^d independently are hydrogen or C_1-C_4 alkyl;

(11) $R^eC(O)$- wherein R^e is C_1-C_4 alkyl or C_1-C_4 alkoxy; or (12) $SO_2NR^cR^d$ wherein R^c and R^d are as defined.

3. The compound of Claim 2 wherein R^7 and R^8 are independently are hydrogen; chlorine; fluorine; bromine; methyl; methoxy; OCF_3; cyano; nitro; trifluoromethyl; R^bSO_n- wherein n is the integer 2 and R^b is methyl, chloromethyl, trifluoromethyl, cyanomethyl, ethyl, or n-propyl; $-NR^cR^d$ wherein R^c and R^d independently are hydrogen or C_1-C_4 alkyl; $R^eC(O)$- where R^e is C_1-C_4 alkyl or C_1-C_4 alkoxy or $SO_2NR^cR^d$ wherein R^c and R^d are as defined and R^7 is in the 3-position.

4. The compounds of Claim 2 wherein R^7 is hydrogen and R^8 is hydrogen, chlorine, bromine, fluorine, CF_3 or R^bSO_2 wherein R^b is C_1-C_4 alkyl.

5. The compound of Claim 2 wherein n is two; R is methyl; R^1 is methyl; R^2 is methyl; R^3 is hydrogen; R^4 is hydrogen; R^5 is hydrogen; R^6 is hydrogen; R^7 is hydrogen; and R^8 is hydrogen.

6. The compound of Claim 2 wherein n is two; R is methyl; R^1 is methyl; R^2 is methyl; R^3 is hydrogen; R^4 is hydrogen; R^5 is methyl; R^6 is hydrogen; R^7 is hydrogen; and R^8 is hydrogen.

7. The compound of Claim 2 wherein n is zero; R is methyl; R^1 is hydrogen; R^2 is hydrogen; R^3 is hydrogen; R^4 is hydrogen; R^5 is hydrogen; R^6 is hydrogen; R^7 is 3-chlorine; and R^8 is chlorine.

8. The compound of Claim 2 wherein n is two; R is methyl; R^1 is hydrogen; R^2 is hydrogen; R^3 is hydrogen; R^4 is hydrogen; R^5 is hydrogen; R^6 is hydrogen; R^7 is 3-chlorine; and R^8 is chlorine.

9. The compound of Claim 2 wherein n is zero; R is methyl; R^1 is hydrogen; R^2 is hydrogen; R^3 is hydrogen; R^4 is hydrogen; R^5 is hydrogen; R^6 is hydrogen; R^7 is hydrogen; and R^8 is trifluoromethyl.

10. The compound of Claim 2 wherein n is two; R is methyl; R^1 is hydrogen; R^2 is hydrogen; R^3 is hydrogen; R^4 is hydrogen; R^5 is hydrogen; R^6 is hydrogen; R^7 is hydrogen; and R^8 is trifluoromethyl.

11. The compound of Claim 2 wherein n is zero; R is methyl; R^1 is methyl; R^2 is methyl; R^3 is hydrogen; R^4 is hydrogen; R^5 is hydrogen; R^6 is hydrogen; R^7 is hydrogen; and R^8 is trifluoromethyl.

12. The compound of Claim 2 wherein n is two; R is methyl; R^1 is methyl; R^2 is methyl; R^3 is hydrogen; R^4 is hydrogen; R^5 is hydrogen; R^6 is hydrogen; R^7 is hydrogen; and R^8 is trifluoromethyl.

13. The compound of Claim 2 wherein n is one; R is methyl; R^1 is methyl; R^2 is methyl; R^3 is hydrogen; R^4 is hydrogen; R^5 is hydrogen; R^6 is hydrogen; R^7 is hydrogen; and R^8 is trifluoromethyl.

14. The compound of Claim 2 wherein n is zero; R is methyl; R^1 is hydrogen; R^2 is hydrogen; R^3 is hydrogen; R^4 is hydrogen; R^5 is hydrogen; R^6 is hydrogen; R^7 is 3-chlorine; and R^8 is methylthio.

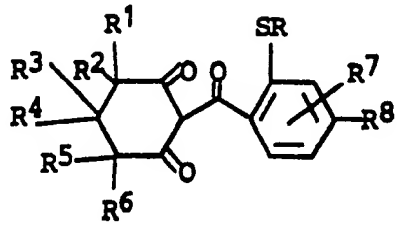
15. The compound of Claim 2 wherein n is one; R is methyl; R^1 is hydrogen; R^2 is hydrogen; R^3 is hydrogen; R^4 is hydrogen; R^5 is hydrogen; R^6 is hydrogen; R^7 is 3-chlorine; and R^8 is $CH_3S(O)$-.

16. The method of controlling undesirable vegetation comprising applying to the area where control is desired, an herbicidally effective amount of a compound of Claims 1-15.

17. An herbicidal composition comprising an herbicidally active 2-(2-C_1-C_4 alkylthio, C_1-C_4 alkylsulfinyl or C_1-C_4 alkylsulfonyl benzoyl)-1,3-cyclohexanedione and an inert carrier therefor.

18. The herbicidal composition of Claim 17 wherein the 2-(2-C_1-C_4 alkylthio, C_1-C_4 alkylsulfinyl or C_1-C_4 alkylsulfonyl benzoyl)-1,3-cyclohexanedione is a compound of Claims 1-15.

19. A process for preparing a compound of the formula



wherein

R is C_1-C_4 alkyl;

R is C_1-C_4 alkyl, optionally substituted with halogen;

R^1 is hydrogen or C_1-C_4 alkyl;

R^2 is hydrogen, C_1-C_4 alkyl or R^a-O-C(=O)- wherein R^a is C_1-C_4 alkyl; or

R^1 and R^2 together are alkylene having 3 to 6 carbon atoms;

R^3 is hydrogen or C_1-C_4 alkyl;

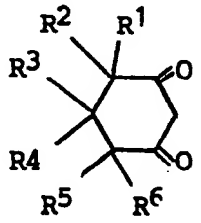
R^4 is hydrogen or C_1-C_4 alkyl;

R^5 is hydrogen or C_1-C_4 alkyl;

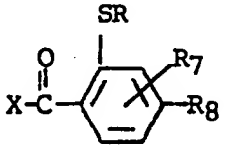
R^6 is hydrogen or C_1-C_4 alkyl; and

R^7 and R^8 independently are (1) hydrogen; (2) halogen; (3) C_1-C_4 alkyl; (4) C_1-C_4 alkoxy; (5) OCF_3; (6) cyano; (7) nitro; (8) C_1-C_4 haloalkyl; (9) R^bSO_n- wherein n is the integer 0, 1 or 2; and R^b is (a) C_1-C_4 alkyl; (b) C_1-C_4 alkyl substituted with halogen or cyano; (c) phenyl; or (d) benzyl; (10) $-NR^cR^d$ wherein R^c and R^d independently are hydrogen or C_1-C_4 alkyl; (11) $R^eC(O)$- wherein R^e is C_1-C_4 alkyl or C_1-C_4 alkoxy; or (12) $SO_2NR^cR^d$ wherein R^c and R^d are as defined, with the proviso that R^7 is not attached to the 6-position comprising

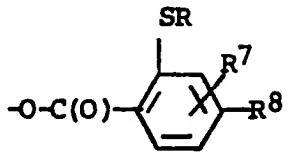
(a) reacting a dione of the formula



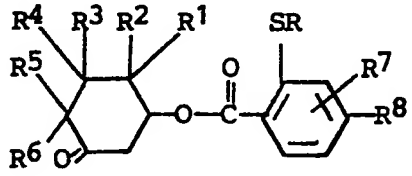
wherein R^1 through R^6 are as defined with a substituted benzoyl reactant of the formula



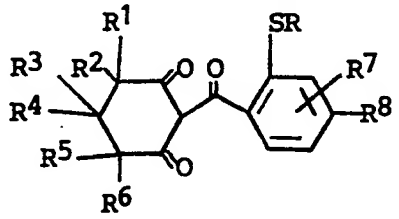
wherein R, R^7 and R^8 are as defined and X is halogen, C_1-C_4 alkyl-C(O)-O-, C_1-C_4 alkoxy-C(O)-O- or



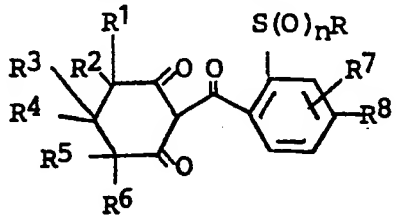
wherein R, R^7 and R^8 in this portion of the molecule are identical with those in the reactant shown above with at least a mole of a moderate base to from an enol ester of the formula



wherein R through R^8 are as defined and in step (2) reacting a mole of the enol ester intermediate with 1 to 4 moles of a moderate base, and from 0.01 mole to about 0.5 mole or higher of a cyanide source to form a 2-C_1-C_4 alkylthiobenzoyl compound of the formula



wherein R^1 through R^8 are as defined above and optionally oxidizing the 2-C_1-C_4 alkylthiobenzoyl compound with a mole or two moles of an oxidizing agent to form a compound of the formula



where R through R^8 are as defined and n is the integer 1 or 2.

20. The process of Claim 19 wherein X is halogen, the moderate base is tri-C_1-C_6 alkylamine, pyridine, alkali metal carbonate or alkali metal phosphate and the cyanide source alkali metal cyanide, cyanohydrins of methyl C_1-C_4 alkyl ketones, cyanohydrins of benzaldehyde or C_2-C_5 aliphatic aldehydes; cyanohydrins, zinc cyanide; tri(lower alkyl) silyl cyanides or hydrogen cyanide.

21. The process of Claim 20 wherein X is chlorine, the moderate base is tri-C_1-C_6 alkylamine, pyridine, sodium carbonate or sodium phosphate and the cyanide source is potassium cyanide, acetone cyanohydrin or hydrogen cyanide.